SECTION 4
HUFFINE LANE CORRIDOR
SPECIFIC ACCESS MANAGEMENT REQUIREMENTS

In order to implement the level of access management required on Huffine Lane to appropriately balance the safety, mobility, and access needs of the corridor, the following specific access management criteria are in force on Huffine Lane between Jackrabbit Lane and College Street in Gallatin County and the City of Bozeman, MT.

Some relevant design criteria from the Montana Department of Transportation Road Design Manual are referenced in several of the paragraphs below, and copies of those pages are included at the end of this section. However, the applicant should confirm and use the latest version of the design manual for planning and design purposes. Applicants should check the Montana Department of Transportation website, at **http://www.mdt.mt.gov/publications/manuals.shtml**, for the latest version of the manual.

1. Number of accesses permitted

Modifications to previously approved accesses will only be considered if the net result of those modifications can be demonstrated - to MDT's satisfaction and based on a thorough technical analysis – that those modifications improve the safety and traffic operations of Huffine Lane. Requesting a change to a previously approved access may, at MDT's discretion, invoke an evaluation of all previously approved access to the parcel in question. In this evaluation, MDT may apply all the concepts of good access management to the parcel, as if no current access existed. Such access management practices include minimizing the number of, or eliminating one or all direct accesses to Huffine Lane if a reasonable alternative access to a local street system currently exists, and enforcing minimum spacing distance standards between adjacent accesses.

Unless otherwise previously agreed to in writing by MDT, no direct access to Huffine Lane shall be approved if other reasonable access can be provided by connections to the adjacent roadway system. The determination of reasonable access to the local street system should include consideration of the street's function, purpose, capacity, and operational and safety considerations. If no such alternative access is available, only one access shall be granted. The only exception to this is if an applicant can demonstrate conclusively - to MDT's sole satisfaction - that safety and operational benefits will ensue if a second access to Huffine Lane is permitted. The burden of proof for this rests on the applicant.

2. Access spacing requirements

The minimum spacing between unsignalized access points is 660 feet. If this spacing is not possible due to parcel size, topographic, or other considerations, the applicant must demonstrate that the location proposed provides the best accommodation given the constraints, and is the best location within those constraints that provides for safety and traffic efficiency on Huffine Lane.

3. Access spacing considerations for accesses in advance of approved U-turn locations or signalized intersections.

If possible, accesses in advance of approved U-turn locations (shown on Figure 2) should be located at least 400 feet in advance of an approved U-turn location, and 550 feet in advance of signalized intersections without U-turns, to prevent unsafe weaving movements.

4. Description of turning movement restrictions

Full turning movements are allowed only at the approved locations shown in Section 3,"Huffine Lane Access Management Plan Details,, approximately one half mile apart. Three quarter turn movements are allowed only at the approved locations shown in Section 3, "Huffine Lane Access Management Plan Details," at approximately quarter mile locations. All other direct access to Huffine Lane must be right in and/or right out only. MDT reserves the right to further restrict three quarter turn intersections to right in/right out if a safety analysis based on a documented safety problem indicates this will eliminate the crash problem.

5. Auxiliary lane requirements

- *Left turn ingress auxiliary lanes will only be allowed at the locations approved for traffic signals or three-quarter turns, or at the east intersection with Arrowhead Trail, as shown in Section 3, "Huffine Lane Access Management Plan Details." At allowable locations, left turn auxiliary lanes shall be designed consistent with Montana Department of Transportation design criteria. Applicable design details can be found later in this section. Figure 28.4K (attached) contains many of the relevant details. Montana Department of Transportation practice for three quarter turn movements is to design for the deceleration length only.*
- *Right turn ingress deceleration lanes shall be sited and designed consistent with Montana Department of Transportation design criteria. Generally, right turn lanes at unsignalized intersections are considered when the thresholds in Figure 28.4B (attached) are met. However, other site specific operational conditions must also be considered, such as capacity, crash history or potential, trucks turning, etc.*

At signalized intersections, both deceleration and storage requirements need to be addressed. Figure 28.4L (attached) and the Highway Capacity Manual queuing analysis is to be used to determine length of storage.

Turn bay development, including taper rates and deceleration lengths are all based on the design speed. For Huffine Lane, the default design speed is 65 mph, unless otherwise determined by the Department.

Right turn egress acceleration lanes are not required on Huffine Lane. The exception to this would be if unusual safety or topographic constraints indicate that a right turn egress acceleration lane would provide safety or traffic operational benefits to Huffine Lane.

6. Access for coordinated parcels

If MDT has previously approved an individual access or access to single parcels that are being coordinated for the purposes of development, the combined parcel will be treated as a single parcel, and access criteria will be applied as if this were a new parcel with no previously approved access.

7. Access for split or divided parcels

Parcels that have previously approved access will receive no new additional access if they are split or divided.

8. Traffic signal requirements

Traffic signals will only be allowed at approved traffic signal locations, shown in the "Huffine Lane Access Management Plan Details" section. MDT will only consider allowing the construction of a traffic signal if at least one of the warrant criteria found in the "Manual of Uniform Traffic Control Devices" is satisfied. If a warrant is satisfied, MDT may require the applicant to provide further documentation demonstrating that a signal is justified based on capacity or safety considerations, now or in the future. The cost to plan, design, and construct any and all traffic signals required to mitigate the impacts of a proposed development or developments to Huffine Lane must be borne by those requesting the development – NOT the Montana Department of Transportation.

9. Sight distance requirements

All access to Huffine Lane shall be designed to provide proper sight distance, per the Montana Department of Transportation design criteria, found the Montana Department of Transportation Design Manual, latest edition. Section 13.4 "Intersection Sight Distance" of the December, 2004 edition of the Montana Design Manual is attached.

10. Corner clearance requirements

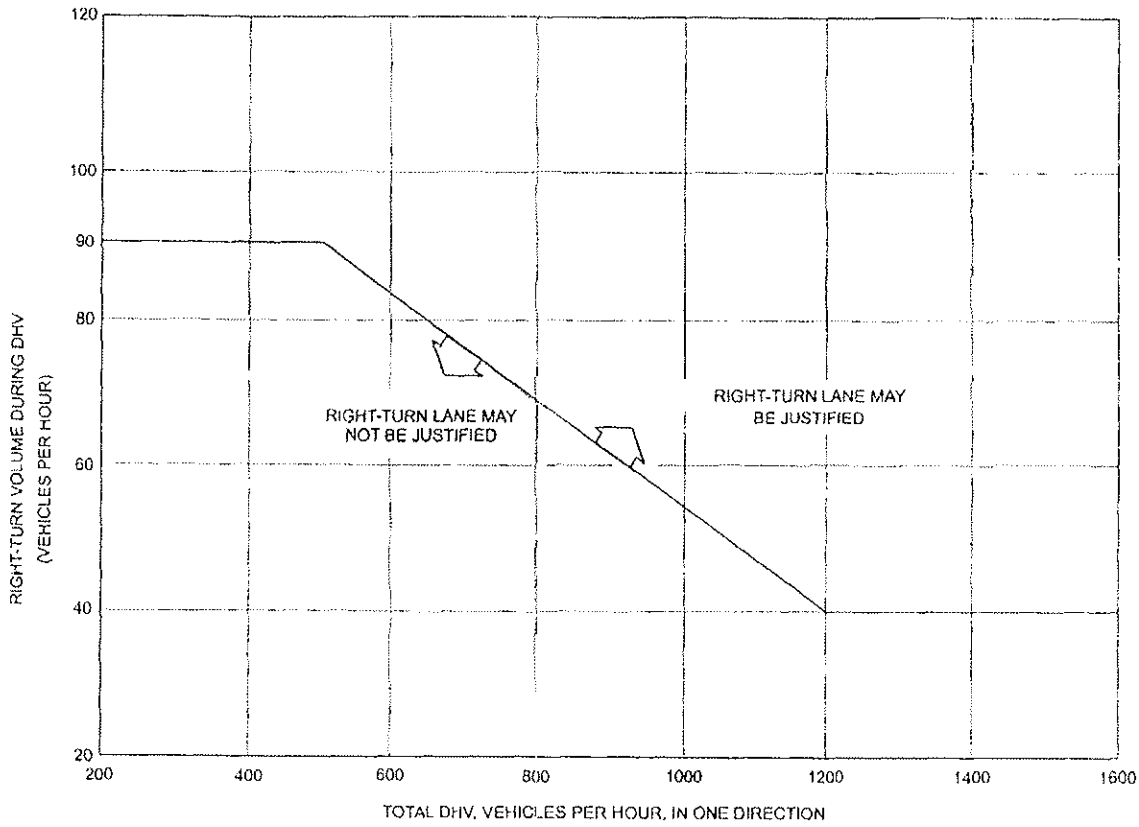
Accesses near or adjacent to public street intersections must be located at least 200 feet away from the intersection (defined by the point of curvature of the nearest curb or radius return). If this is not possible due to property frontage reasons, the access must be located as far from the intersection as possible – generally, within ten feet of the next adjacent property line.

11. Intersecting street requirements

In order to minimize traffic congestion and potential accident problems on north-south public or private streets that intersect Huffine Lane, it is recommended that all streets intersecting these north-south streets shall be at least 300 feet back from the extended flowline of Huffine Lane. It is further recommended that direct parcel access to the north-south street intersecting Huffine Lane shall not be allowed within 300 feet of the extended flowline of Huffine Lane.

12. Permission required for any and all work within the Montana Department of Transportation right-of-way on Huffine Lane.

It is required that permission to perform any and all work within the Montana Department of Transportation right-of-way for Huffine Lane be secured from the Montana Department of Transportation Maintenance Chief PRIOR to the commencement of any such work. The Maintenance Chief can be contacted at 406-556-4700.



Note: Figure is only applicable on highways with a design speed of 50 mph (80 km/h) or greater.

GUIDELINES FOR RIGHT-TURN LANES AT UNSIGNALIZED INTERSECTIONS ON 4-LANE HIGHWAYS

Figure 28.4B

28.4.2 Design of Turn Lanes

28.4.2.1 Widths

The following will apply to auxiliary turn lane widths:

1. Lane Widths. Typically, the width of any turn lanes at an intersection is the same as that of the adjacent through lane. In rare cases, it may be justified to provide a narrower width (e.g., restricted right-of-way).

2. Shoulder. The designer should meet the following for shoulders adjacent to auxiliary lanes:

   a. On uncurbed facilities, the shoulder width adjacent to the auxiliary lane should be the same as the normal shoulder width for the approaching roadway. At a minimum, the width may be 4 ft (1.2 m), assuming the roadway has a shoulder width equal to or greater than 4 ft (1.2 m).

   b. On curbed facilities, the offset between the auxiliary lane and face of curb should be the same as that for the normal roadway section, typically 2 ft (0.6 m). At a minimum, the offset may be 1 ft (0.3 m).

3. Cross Slope. The cross slope for an auxiliary lane will typically be the same as the adjacent through lane, which is typically 2%.

28.4.2.2 Turn Lane Lengths

The length of a right- or left-turn lane at an intersection should allow for both safe vehicular deceleration and storage of turning vehicles. This is the Department's minimum design at rural intersections. However, for urban facilities, it may be impractical to provide a turn lane length that provides for deceleration. Therefore, the full-width, turn-lane length may be designed to only provide sufficient distance for storage at urban intersections. To determine the turn lane length, the designer should consider the following:

1. Taper. For tapers, the following will apply:

   a. Design. A straight-line taper is typically used at the entrance of the turn lane.

   b. NHS Routes. The taper length is in addition to the deceleration distance as described in Comment #2 (i.e., the deceleration is assumed to begin after the taper).

c. Non-NHS Routes. The taper distance is included in the deceleration distance as described in Comment #2; (i.e., deceleration is assumed to begin at the beginning of the taper).

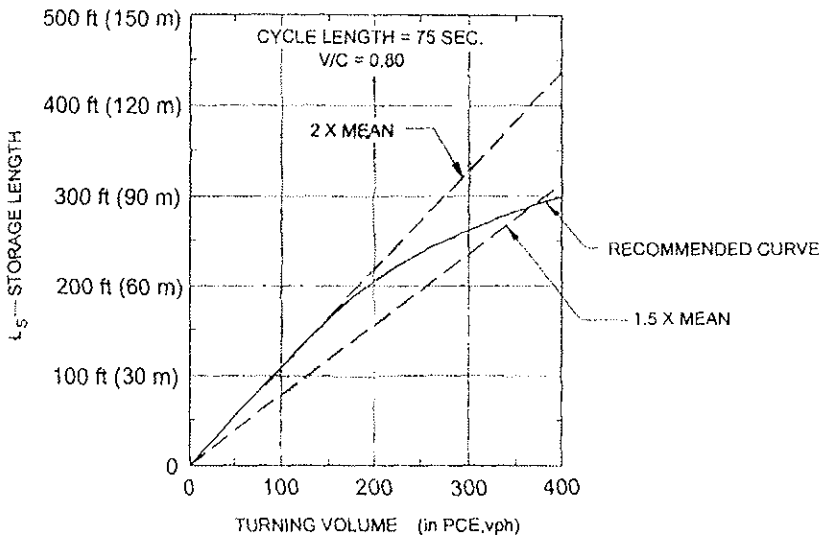
d. Taper Rates. Figure 28.4G provides the recommended taper rates for various design speeds.

2. Deceleration. For rural facilities, the deceleration distance (L_D) should meet the criteria presented in Figure 28.4H. This assumes that the driver will come to a complete stop before turning. For turning roadways, it can be assumed that the driver will be making the right turn at 15 mph (20 km/h). The deceleration distances for 15 mph (20 km/h) are also presented in Figure 28.4H. These distances are desirable on urban facilities; however, this is not always feasible. Under restricted urban conditions and where the design speed is less than or equal to 45 mph (70 km/h), deceleration may have to be accomplished entirely within the travel lane. For these cases, the length of turn lane will be determined solely on the basis of providing adequate vehicular storage (i.e., L_D = 0.0 ft (0.0 m)).

3. Storage. The storage length (L_S) for turn lanes should be sufficient to store the number of vehicles likely to accumulate. The designer should consider the following in determining the recommended storage length:

a. Signalized Intersections. Figure 28.4I illustrates the method to determine the recommended storage length for left-turn lanes, or right-turn lanes where right-turn-on-red is prohibited at a signalized intersection. The values obtained from the figure are for a cycle length of 75 seconds and a volume/capacity (*v/c*) ratio of 0.80. For other values, the designer should multiply the length obtained in the figure by an adjustment factor found in the accompanying table with Figure 28.4I. The *v/c* ratio is determined by a capacity analysis as described in the Highway Capacity Manual. The designer should also ensure at signalized intersections that the right- and left-turn lane lengths exceed the storage length of the adjacent through lane. Otherwise, a vehicular queue in the through lane will block entry into the turn lane for turning vehicles. Most capacity software packages have a queuing model available. Use engineering judgment to determine the appropriate method to use to determine storage requirements.

b. Unsignalized Intersections. The minimum storage length should be sufficient to accommodate the expected number of turning vehicles likely to arrive in an average 2 minute period within the design hour. The



Storage Length Adjustment Factors

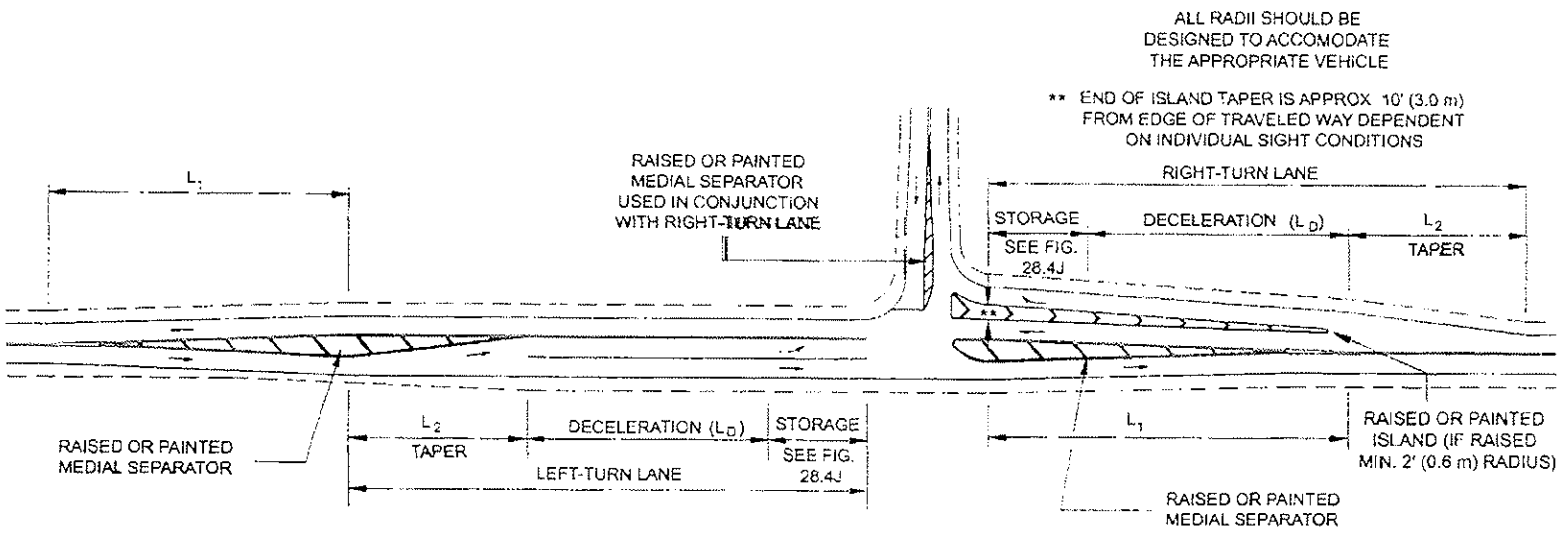
v/c RATIO, X	CYCLE LENGTH, C (SEC)				
	60	70	80	90	100
0.50	0.70	0.76	0.84	0.89	0.94
0.55	0.71	0.77	0.85	0.90	0.95
0.60	0.73	0.79	0.87	0.92	0.97
0.65	0.75	0.81	0.89	0.94	1.00
0.70	0.77	0.84	0.92	0.98	1.03
0.75	0.82	0.88	0.98	1.03	1.09
0.80	0.88	0.95	1.05	1.11	1.17
0.85	0.99	1.06	1.18	1.24	1.31
0.90	1.17	1.26	1.40	1.48	1.56
0.95	1.61	1.74	1.92	2.03	2.14

Notes:

1. *Figure applies to exclusive left-turn lanes and exclusive right-turn lanes where right-turns-on-red are not allowed.*
2. *See minimum storage length discussion in Section 28.4.2.2.*
3. *To determine the v/c ratio and the passenger car equivalent (PCE) values, see the Highway Capacity Manual.*
4. *If turning volumes exceed 300 vph, consider providing dual-turn lanes.*

RECOMMENDED STORAGE LENGTH FOR SIGNALIZED INTERSECTIONS

Figure 28.4I



Design Speed (mph)	Taper Rate	
	Lane Shifts (L_1)	Auxiliary Lanes (L_2)
20	10:1	8:1
25	15:1	8:1
30	20:1	8:1
35	25:1	10:1
40	40:1	10:1
45	45:1	10:1
50	50:1	15:1
55	55:1	18:1
60	60:1	18:1
65	65:1	18:1
70	70:1	18:1
75	75:1	18:1

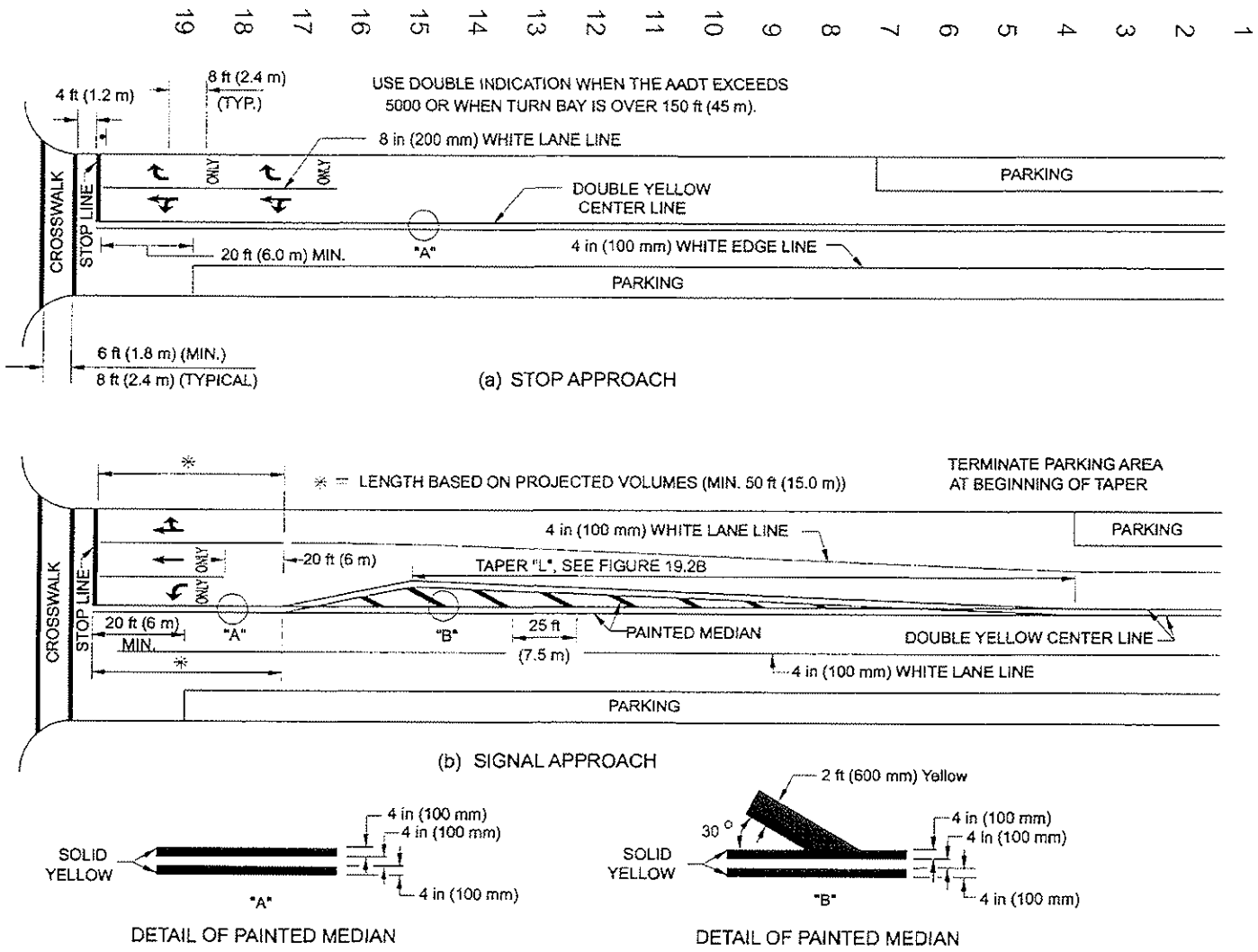
Taper Length (L) = Taper Rate x Offset Distance
See Section 28.4.2.2 for minimum left-turn lane lengths.

Design Speed (mph)	Average Running Speed (mph)(1)	L_D(ft)(2)	
		Stop Condition	15 mph
25	25	200	185
30	28	235	200
35	32	280	250
40	36	320	295
45	40	385	350
50	45	435	405
55	48	480	455
60	52	530	500
65	55	570	540
70	58	615	590

(1) Average running speeds assumed for calculations.
(2) Bay taper may be included in the deceleration length on non-NHS projects.

CHANNELIZED TURN LANES FOR 2-LANE FACILITIES
(US Customary)

Figure 28.4K



TYPICAL INTERSECTION LANE-USE CONTROL MARKINGS

Figure 19.4D

13.4 INTERSECTION SIGHT DISTANCE

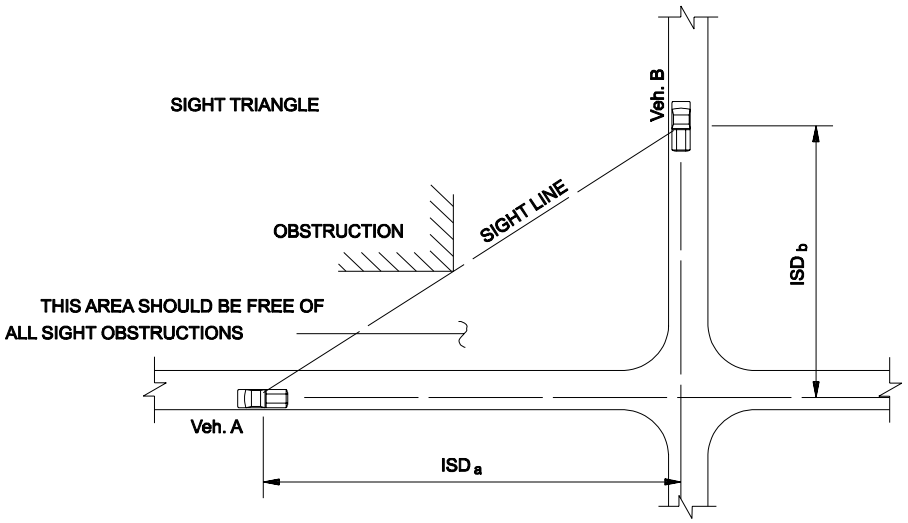
For an at-grade intersection to operate properly, adequate sight distance should be available. The designer should provide sufficient sight distance for a driver to perceive potential conflicts and to perform the actions needed to negotiate the intersection safely. The additional costs and impacts of removing sight obstructions are often justified. If it is impractical to remove an obstruction blocking the sight distance, the designer should consider providing traffic control devices or design applications (e.g., warning signs, turn lanes) which may not otherwise be considered.

In general, ISD refers to the corner sight distance available in intersection quadrants which allows a driver approaching an intersection to observe the actions of vehicles on the crossing leg(s). ISD evaluations involve establishing the needed sight triangle in each quadrant by determining the legs of the triangle on the two crossing roadways. The necessary clear sight triangle is based on the type of traffic control at the intersection and on the design speeds of the two roadways.

The Department uses gap acceptance as its basic concept in the design of intersection sight distance. This gap acceptance design is based on the criteria and theory presented in NCHRP Report 383, *Intersection Sight Distance*.

13.4.1 No Traffic Control

Intersections between low-volume and low-speed roads/streets may have no traffic control. At these intersections, sufficient corner sight distance should be available to allow approaching vehicles to adjust their speed to avoid a collision, typically 50 percent of their mid-block running speed. Figure 13.4A provides the ISD criteria for intersections with no traffic control. For approach grades greater than 3%, adjust the ISD values obtained in Figure 13.4A with the applicable ratios in Figure 13.4B.



Design Speed (mph)	15	20	25	30	35	40	45	50
*Intersection Sight Distance (ft)	70	90	115	140	165	195	220	245
Design Speed (km/h)	20	30	40	50	60	70	80	90
*Intersection Sight Distance (m)	20	25	35	45	55	65	75	90

Note: For approach grades greater than 3%, multiply the sight distance values in this table by the appropriate adjustment factor from Figure 13.4B. The grade adjustment is based on the approach roadway grade only.

Example

Given: No traffic control at intersection

	U.S. Customary	Metric
Design speed	35 mph (Highway A)	60 km/h (Highway A)
	25 mph (Highway B)	40 km/h (Highway B)

Problem: Determine legs of sight triangle.

Solution: From above table ---ISD_a = 165' ISD_a = 55 m

ISD_b = 115' ISD_b = 35 m

Note: This figure is not applicable for State highways.

INTERSECTION SIGHT DISTANCE
(No Traffic Control)
Figure 13.4A

U.S. Customary

Approach Grade (%)	Design Speed (mph)										
	20	25	30	35	40	45	50	55	60	65	70
-6	1.1	1.1	1.1	1.1	1.1.	1.1	1.2	1.2	1.2	1.2	1.2
-5	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2
-4	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
-3 to +3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
+4	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
+5	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
+6	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Metric

Approach Grade (%)	Design Speed (km/h)									
	30	40	50	60	70	80	90	100	110	120
-6	1.1	1.1	1.1	1.1	1.1.	1.2	1.2	1.2	1.2	1.2
-5	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2
-4	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
-3 to +3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
+4	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
+5	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
+6	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Note: Based on ratio of stopping sight distance on specified approach grade to stopping sight distance on level terrain. The grade adjustment is based on the approach roadway grade only.

ADJUSTMENT FACTORS FOR APPROACH SIGHT DISTANCE BASED ON APPROACH GRADE

Figure 13.4B

13.4.2 Stop Controlled/Traffic-Signal Controlled

Where traffic on the minor road of an intersection is controlled by stop signs, the driver of the vehicle on the minor road must have sufficient sight distance for a safe departure from the stopped position assuming that the approaching vehicle comes into view as the stopped vehicle begins its departure.

The stopped-controlled criteria required will also apply to a signalized intersection. This is reasonable because of the increased driver work load at intersections and the potential conflicts involved when vehicles turn onto or cross the highway. These include:

1. violation of the signal,
2. right-turns-on-red,
3. signal malfunction, and/or
4. use of flashing yellow/red mode during part of the day.

If these criteria cannot be met, give consideration to prohibiting right-turn-on-red at the intersection or prohibiting the flashing mode. This determination will be based on field investigations and will be determined on a case-by-case basis.

13.4.2.1 Basic Criteria

The Department uses gap acceptance as the conceptual basis for its intersection sight distance (ISD) criteria at stop-controlled and traffic-signal controlled intersections. The intersection sight distance is obtained by providing clear sight triangles both to the right and left as shown in Figure 13.4C. The length of legs of these sight triangles are determined as follows:

1. Minor Road. The length of leg along the minor road is based on two parts. The first is the location of the driver's eye on the minor road. This is typically assumed to be 14.4' (4.4 m) from the edge of traveled way for the major road and in the center of the lane on the minor road; see Figure 13.4C. The second part is based on the distance to the center of the vehicle on the major road. For right-turning vehicles, this is assumed to be the center of the closest travel lane from the left. For left-turning vehicles, this is assumed to be the center of the closest travel lane for vehicles approaching from the right; see Figure 13.4C.

2. Major Road. The length of the sight triangle leg or ISD along the major road is determined using the following equation:

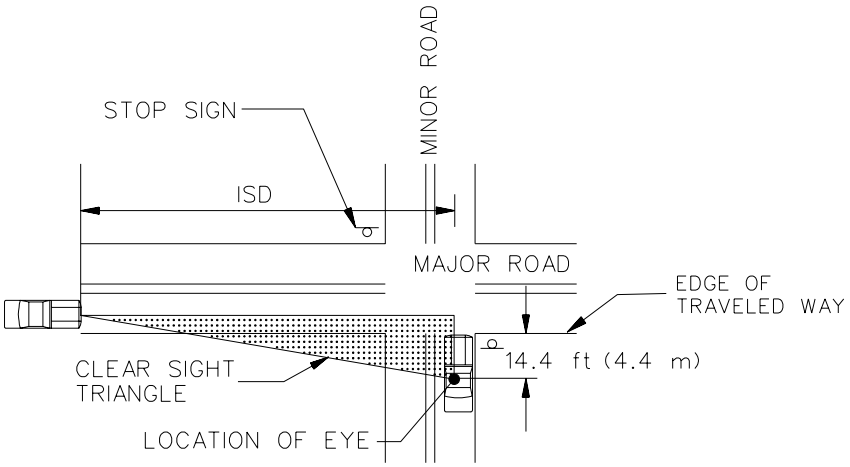
U.S. Customary *Metric*

$ISD = 1.47\ V_{major}\ t_g$ $ISD = 0.278\ V_{major}\ t_g$ (Equation 13.4-1)

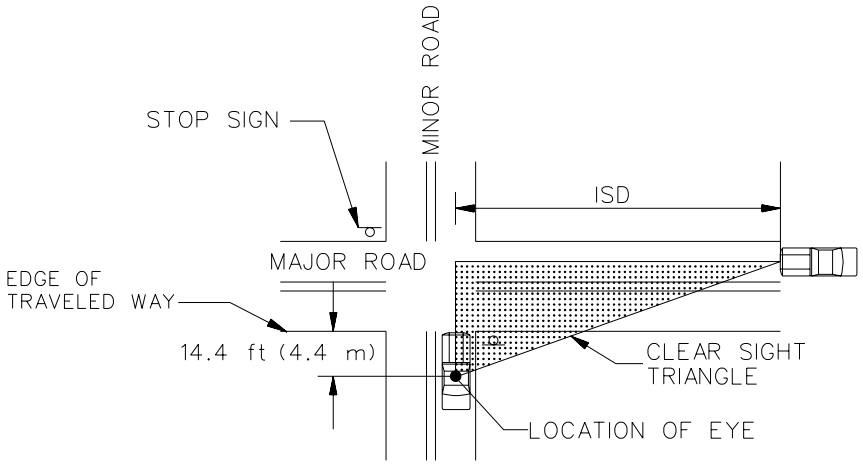
Where:

ISD = length of sight triangle leg along major road [ft (m)]
V_{major} = design speed of major road [mph (km/h)]
t_g = gap acceptance time for entering the major road (sec)

The gap acceptance time (t_g) varies according to the design vehicle, the grade on the minor road approach, the number of lanes on the major roadway, the type of operation and the intersection skew. Section 13.4.2.4 presents several examples on the application of ISD.



CLEAR SIGHT TRIANGLE FOR VIEWING
TRAFFIC APPROACHING FROM THE LEFT



CLEAR SIGHT TRIANGLE FOR VIEWING
TRAFFIC APPROACHING FROM THE RIGHT

CLEAR SIGHT TRIANGLES (STOP-CONTROLLED) INTERSECTIONS

Figure 13.4C

Within this clear sight triangle, if practical, the objective is to remove, lower any object or trim lower branches that obstructs the driver's view. These objects may include buildings, parked or turning vehicles, trees, hedges, tall crops, un-mowed grass, fences, retaining walls and the existing ground line. In addition, where an interchange ramp intersects the major road or crossroad near a bridge on a crest vertical curve, objects such as bridge parapets, piers, abutments or the crest vertical curve itself may restrict the clear sight triangle.

13.4.2.2 Vehicle Entering Major Roadway

To determine the intersection sight distance for vehicles turning left or right onto the major road, the designer should use Equation 13.4-1 and the gap acceptance time (t_g) presented in Figure 13.4D. Figure 13.4E, which solves Equation 13.4-1, provides the ISD values for all design vehicles on 2-lane, level facilities. The designer should also consider the following:

1. Turn Maneuver. There is only a minimal difference in the gap acceptance times between the left- and right-turning drivers. Therefore, only one gap acceptance time is provided.

2. Multilane Facilities. For multilane facilities, the gap acceptance times presented in Figure 13.4D should be adjusted to account for the additional distance required by the turning vehicle to cross the additional lanes or median. The following will apply:

    a. Left-Turns. For left turns onto multilane highways, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane, in excess of one, to be crossed by the turning vehicle. Assume that the left-turning driver will enter the left travel lane on the far side of the major road. For example, the gap acceptance time for a passenger car turning left onto an undivided six-lane facility would be 7.5 seconds plus 0.5 seconds for each of the two additional lanes needed to be crossed. The total gap time required is therefore 8.5 seconds.

    b. Right Turns. Because the turning vehicle is assumed to be turning into the nearest right through lane, no adjustments to the gap times are required.

3. Medians. For a multilane facility which does not have a median wide enough to store a stopped vehicle, divide the median width by 12' (3.6 m) to determine the corresponding number of lanes, and then use the criteria in Comment #2a above to determine the appropriate time factor.

On multilane facilities with a median wide enough to store the stopped vehicle, the designer should evaluate the move in two steps; see Figure 13.4F:

a. First, with the vehicle stopped on the minor road (the bottom portion in Figure 13.4F), use the gap acceptance times and distances for a vehicle turning right (Figures 13.4D and 13.4E) to determine the applicable ISD. Under some circumstances, it may be necessary to check the crossing maneuver to determine if it is the critical movement. Crossing criteria are discussed in Section 13.4.2.3.

b. Then, with the vehicle stopped in the median (top portion in Figure 13.4F), assume a two-lane roadway design and use the gap acceptance times and distances for vehicles turning left (Figures 13.4D and 13.4E) to determine the applicable ISD.

4. Approach Grades. If the approach grade on the minor road exceeds +3%, add the following times to the basic gap acceptance times in Figure 13.4D:

a. Left Turns. Multiply the percent grade on the approach by 0.2 and add this to the base time gap.

b. Right Turns. Multiply the percent grade on the approach by 0.1 and add this to the base time gap. Use the adjusted t_g in Equation 13.4-1 to determine the applicable ISD. Do not apply the grade adjustment if the approach grade is negative.

Design Vehicle	Gap Acceptance Time (t_g) (sec)
Passenger Car	7.5
Single-Unit Truck	9.5
Tractor/Semitrailer	11.5

GAP ACCEPTANCE TIMES
(Right or Left Turn From Minor Road)

Figure 13.4D

U.S. Customary(Rounded for Design)

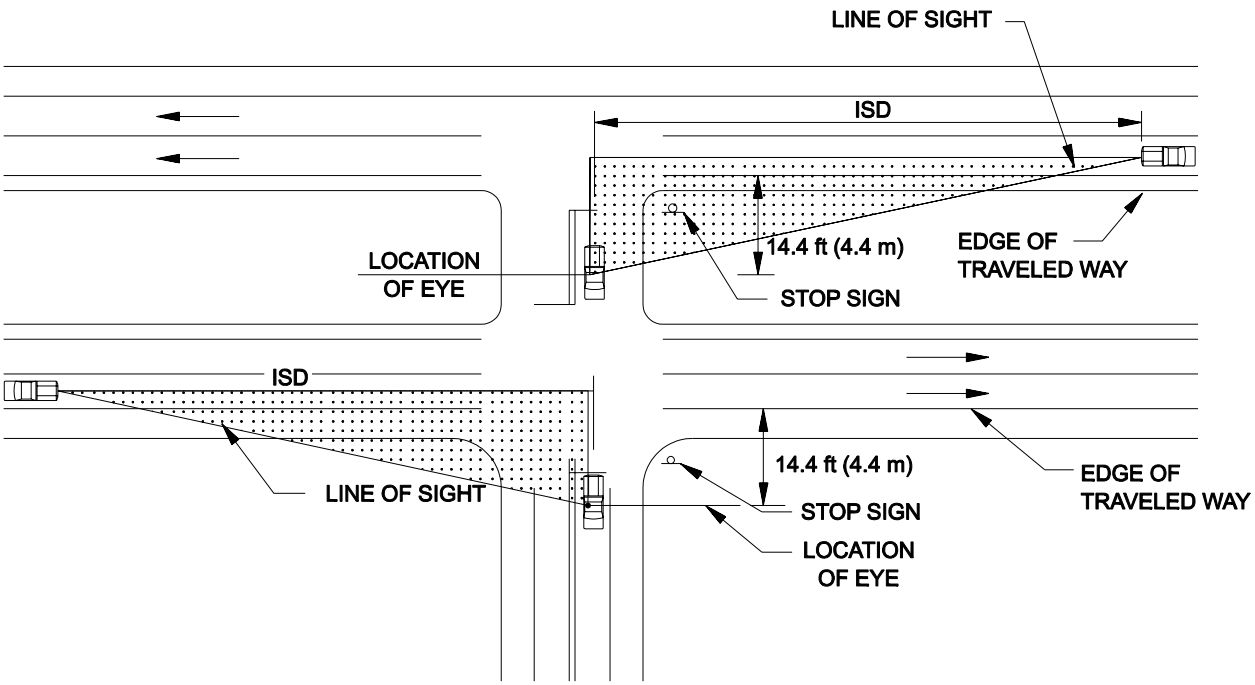
Design Speed (V_{major}) (mph)	ISD (ft)		
	Passenger Cars	Single-Unit Trucks	Tractor/Semitrailers
20	225	280	340
25	280	350	425
30	335	420	510
35	390	490	595
40	445	560	680
45	500	630	765
50	555	700	850
55	610	770	930
60	665	840	1015
65	720	910	1100
70	775	980	1185

Metric(Rounded for Design)

Design Speed (V_{major}) (km/h)	ISD (m)		
	Passenger Cars	Single-Unit Trucks	Tractor/Semitrailers
30	65	80	100
40	85	110	130
50	105	135	160
60	130	160	195
70	150	185	225
80	170	215	260
90	190	240	290
100	210	265	320
110	230	295	355

Note: These ISD values assume a minor road approach grade $\leq$ +3%.

TWO-LANE INTERSECTION SIGHT DISTANCES
(Right or Left Turn from Minor Road)
Figure 13.4E



INTERSECTION SIGHT DISTANCE
(Divided Facilities) Figure 13.4F

5. Trucks. At some intersections (e.g., near truck stops, interchange ramps, grain elevators), the designer may want to use the truck as the design vehicle for determining the ISD. The gap acceptance times (t_g) for single-unit and tractor/ semitrailer trucks are provided in Figure 13.4D. ISD values for level, 2-lane roadways are presented in Figure 13.4E.

6. Height of Eye/Object. The height of eye for passenger cars is assumed to be 3.5' (1080 mm) above the surface of the minor road. The height of object (approaching vehicle on the major road) is also assumed to be 3.5' (1080 mm). An object height of 3.5' (1080 mm) assumes that a sufficient portion of the oncoming vehicle must be visible to identify it as an object of concern by the minor road driver. If there is a sufficient number of trucks to warrant their consideration, assume an eye height of 7.9' (2.4 m) for a tractor/semitrailer and 5.9' (1.8 m) for single-unit trucks and buses. If a truck is the assumed entering vehicle, the object height will still be 3.5' (1080 mm) for the passenger car on the major road.

7. Skew. At skewed intersections where the intersection angle is less than 60°, adjustments may need to be made to account for the extra distance the vehicle needs to travel across opposing lanes. Using the procedures discussed in Comment #2 in Section 13.4.2.2 and/or Section 13.4.2.3, determine the appropriate ISD value based on this extra travel distance.

8. Examples. For examples on the application of ISD, see Section 13.4.2.4.

13.4.2.3 Straight Through Crossing Vehicle

In the majority of cases, the intersection sight distance for turning vehicles typically will provide adequate sight distance to allow a vehicle to cross the major road. However, in the following situations, the crossing sight distance may be the more critical movement:

1. where left and/or right turns are not permitted from a specific approach and the crossing maneuver is the only legal or expected movement (e.g., indirect left turns);

2. where the design vehicle must cross more than six travel lanes or, with medians, the equivalent distance; or

3. where a substantial volume of heavy vehicles cross the highway and there are steep grades on the minor road approach.

Use Equation 13.4-1 and the gap acceptance times (t_g) and the adjustment factors in Figure 13.4G to determine the ISD for crossing maneuvers. Where medians are present, include the median width in the overall length to determine the applicable gap time. Divide this width by 12' (3.6 m) to determine the corresponding number of lanes for the crossing maneuver.

Design Vehicle	Gap Acceptance Time (t_g) (sec)
Passenger Car	6.5
Single-Unit Truck	8.5
Tractor/Semitrailer	10.5

Adjustments:

1. *Multilane Highway. Where the design vehicle is crossing a major road with more than two lanes, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane in excess of two. See the discussion in Section 13.4.2.2 for additional guidance.*

2. *Approach Grade. If the approach grade on the minor road exceeds +3%, multiply the percent grade of the minor road approach by 0.2 and add it to the base gap acceptance time.*

GAP ACCEPTANCE TIMES
(Crossing Maneuvers)

Figure 13.4G

13.4.2.4 Examples of ISD Applications

The following three examples illustrate the application of the ISD criteria:

Example 13-1

Given: Minor road intersects a 4-lane highway with a TWLTL.
Minor road is stop controlled.
Design speed of the major highway is 50 mph (80 km/h).
All travel lane widths are 12' (3.6 m).
The TWLTL width is 14' (4.2 m).
Trucks are not a concern.

Problem: Determine the intersection sight distance to the left and right from the minor road.

Solution: The following steps will apply:

1. For the vehicle turning right, the ISD to the left can be determined directly from Figure 13.4E. For the 50 mph design speed, the ISD to the left is 555'. For the 80 km/h design speed, the ISD to the left is 170 m.

2. For the vehicle turning left, the ISD must reflect the additional time required to cross the additional lanes; see Comment #2 in Section 13.4.2.2. The following will apply:

   a. First, determine the extra width required by the one additional travel lane and the TWLTL and divide this number by 12' (3.6 m):

   U.S. Customary

   $$\frac{(12+14)}{12} = 2.2 \text{ lanes}$$

   Metric

   $$\frac{(3.6+4.2)}{3.6} = 2.2 \text{ lanes}$$

   b. Next, multiply the number of lanes by 0.5 seconds to determine the additional time required:

   (2.2 lanes)(0.5 sec/lane) = 1.1 seconds

   c. Add the additional time to the basic gap time of 7.5 seconds and insert this value into Equation 13.4-1:

U.S. Customary ISD = (1.47)(50)(7.5 + 1.1) = 632’

Metric ISD = (0.278)(80)(7.5 + 1.1) = 191 m

Provide an ISD of 630’ (190 m) to the right for the left-turning vehicle.

3. Check the crossing vehicle, as discussed in Section 13.4.2.3. The following will apply:

   a. First determine the extra width required by the two additional travel lanes and the TWLTL and divide this number by 12’ (3.6 m):

   U.S. Customary

   $$\frac{(12+12+14)}{12} = 3.2 \text{ lanes}$$

   Metric

   $$\frac{(3.6+3.6+4.2)}{3.6} = 3.2 \text{ lanes}$$

   b. Next, multiply the number of lanes by 0.5 seconds to determine the additional time required:

   (3.2 lanes)(0.5 sec/lane) = 1.6 seconds

   c. Add the additional time to the basic gap time of 6.5 seconds and insert this value into Equation 13.4-1:

   U.S. Customary ISD = (1.47)(50)(6.5 + 1.6) = 595’

   Metric ISD = (0.278)(80)(6.5 + 1.6) = 180 m

   The 595’ (180 m) for the crossing maneuver is less than the 630’ (190 m) required for the left-turning vehicle and, therefore, is not the critical maneuver.

Example 13-2

Given: Minor road intersects a 4-lane divided highway.
Minor road is stop controlled.
Design speed of the major highway is 55 mph (90 km/h).
All travel lane widths are 12’ (3.6 m).
The median width is 100’ (30.8 m).
Trucks are not a concern.

Problem: Determine the intersection sight distance to the left and right from the minor road.

Solution: The following steps apply:

1. For the vehicle turning right, the ISD to the left can be determined directly from Figure 13.4E. For the 55 mph design speed, the ISD to the left is 610'. For the 90 km/h design speed, the ISD to the left is 190 m.

2. Determine if the crossing maneuver is critical; see Section 13.4.2.3. No adjustments are required to the base time of 6.5 seconds. Therefore, use Equation 13.4-1 directly:

   U.S. Customary ISD = (1.47)(55)(6.5) = 525'

   Metric ISD = (0.278)(90)(6.5) = 163 m

   The crossing maneuver is less than the right-turning maneuver and, therefore, is not critical.

3. For the vehicle turning left, assume the passenger car is stopped in the median; see Figure 13.4F. The ISD to the right can be determined directly from Figure 13.4E. For the 55 mph design speed, the ISD to the left is 610'. For the 90 km/h design speed, the ISD to the left is 190 m. . The crossing maneuver will not be critical.

Example 13-3

Given: Minor road intersects a 2-lane highway.
Minor road is stop controlled.
Design speed of the major highway is 55 mph (90 km/h).
All travel lane widths are 12' (3.6 m).
The approach grade on the minor road is 4.5%.
Tractor/semitrailer trucks are a concern.

Problem: Determine the intersection sight distance to the left and right from the minor road.

Solution: The following steps will apply:

1. For the left-turning vehicle, the base gap acceptance time from Figure 13.4D is 11.5 seconds. Add the additional time due to the approach grade (0.2 seconds per percent grade) to the base gap time; see Comment #4 in Section 13.4.2.2:

(0.2)(4.5) + 11.5 = 12.4 seconds

Then, using Equation 13.4-1:

U.S. Customary ISD = (1.47)(55)(12.4) = 1003'

Metric ISD = (0.278)(90)(12.4) = 310 m

The ISD for the right-turning vehicle is determined similarly:

(0.1)(4.5) + 11.5 = 12 seconds

Then, using Equation 13.4-1:

U.S. Customary ISD = (1.47)(55)(12.0) = 970'

Metric ISD = (0.278)(90)(12.0) = 300 m

The crossing maneuver will not be critical.

13.4.3 Yield Control

At intersections controlled by a yield sign, drivers on the minor road will typically:

1. slow down as they approach the major road, typically to 60 percent of the approach speed;

2. based on their view of the major road, make a stop/continue decision; and

3. either brake to a stop or continue their crossing or turning maneuver onto the major road.

Yield control criteria is based on a combination of the no control ISD discussed in Section 13.4.1 and the stop-controlled ISD as discussed in Section 13.4.2. To determine the applicable clear sight triangles of the approaches, the following will apply; see Figure 13.4H:

1. Crossing Maneuver. Use the following to determine the legs of the clear sight triangle; Illustration a in Figure 13.4H:

    a. Minor Road. The leg on the minor road approach can be determined directly from Figure 13.4I.

b. Major Road. The leg on the major road is determined using the following equations and the times listed in Figure 13.4I:

U.S. Customary	Metric
$t_g = t_a + \frac{w + L_a}{0.88(V_{\text{minor}})}$	$t_g = t_a + \frac{w + L_a}{0.167(V_{\text{minor}})}$
$b = (1.47)(V_{major})(t_g)$	$b = (0.278)(V_{major})(t_g)$

Where:

b = length of leg of sight triangle along the major road ft (m)

t_g = travel time to reach and clear the major road in a crossing maneuver (sec)

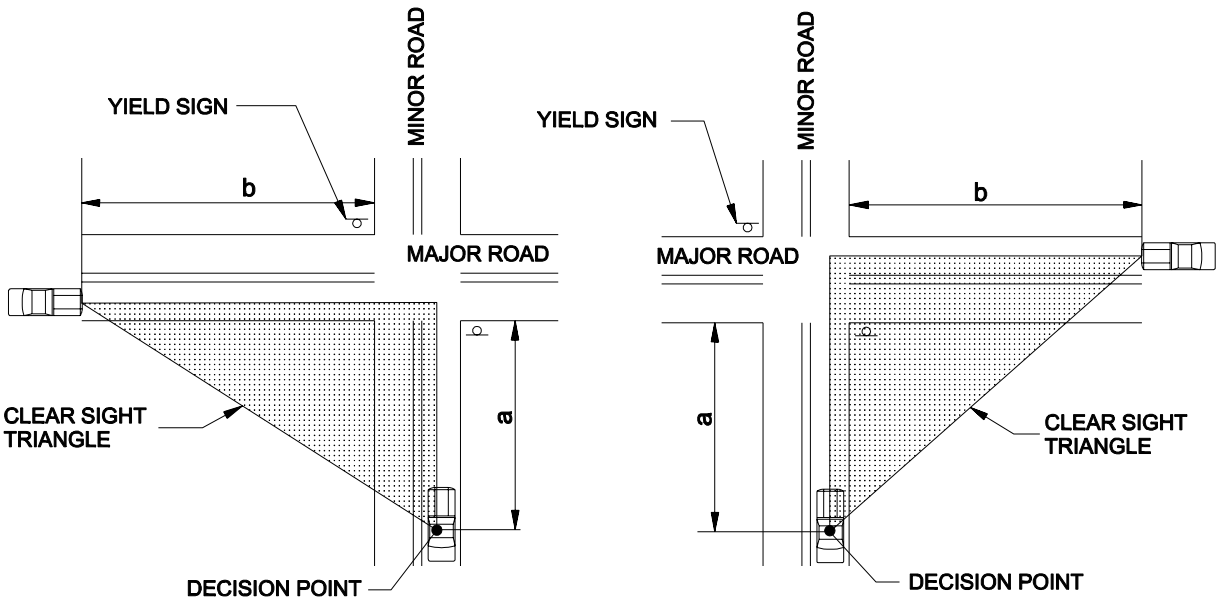
t_a = travel time to reach the major road from the decision point for a vehicle that does not stop(sec) (use appropriate value for the minor-road design speed from Figure 13.4I, adjusted for approach grade, where appropriate)

w = width of intersection to be crossed ft (m)

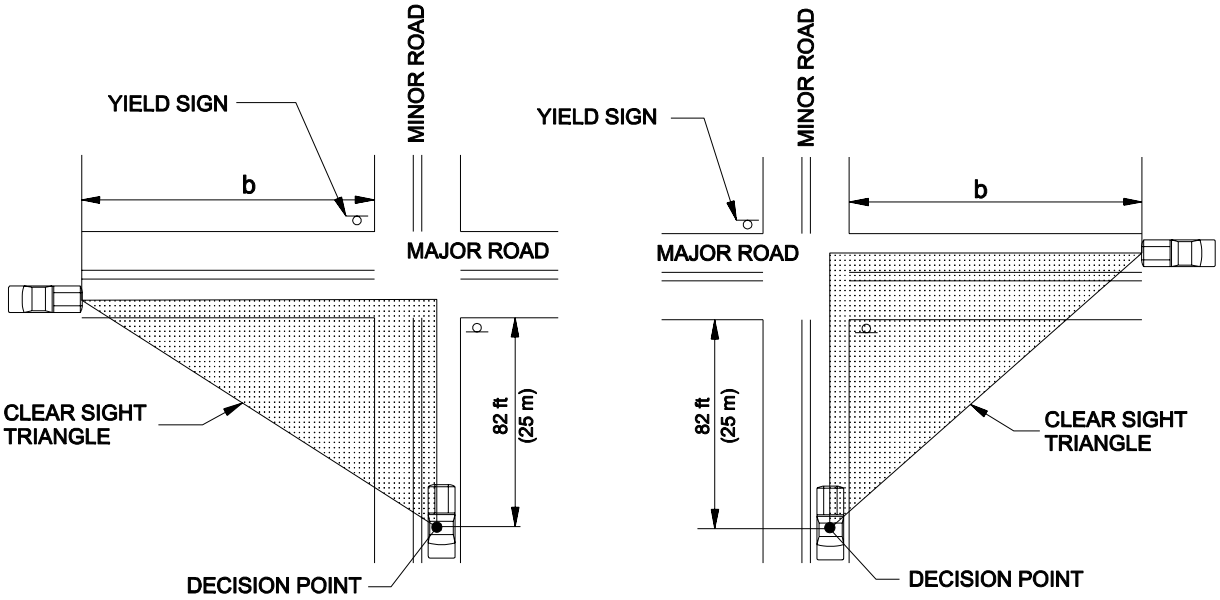
L_a = length of design vehicle ft (m)

V_{minor} = design speed of minor road mph (km/h)

V_{major} = design speed of major road mph (km/h)



a) CROSSING MANEUVERS



b) TURNING MANEUVERS

INTERSECTION SIGHT DISTANCE APPLICATION
(Yield Control)

Figure 13.4H

U.S. Customary

Design Speed (mph)	Approach Distance Along Minor Road[(1)] (a)(ft)	Travel Time From Decision Point to Major Road (t_a)[(1)(2)] (sec)
20	100	3.7
25	130	4.0
30	160	4.3
35	195	4.6
40	235	4.9
45	275	5.2
50	320	5.5
55	370	5.8
60	420	6.1
65	470	6.4
70	530	6.7

Metric

Design Speed (km/h)	Approach Distance Along Minor Road[(1)] (a)(m)	Travel Time From Decision Point to Major Road (t_a)[(1)(2)] (sec)
30	30	3.6
40	40	4.0
50	55	4.4
60	65	4.8
70	80	5.1
80	100	5.5
90	115	5.9
100	135	6.3
110	155	6.7

(1) For minor-road approach grades that exceed 3%, multiply by the appropriate adjustment factor from Figure 13.4B. Do not apply the adjustment factor to approaches with negative grades.

(2) Travel time applies to a vehicle that slows before crossing the intersection but does not stop.

ISD ASSUMPTIONS FOR YIELD CONTROLLED INTERSECTION (Crossing Maneuver)

Figure 13.4I

2. Turning Maneuvers. For the turning left or right vehicle, the approach legs are determined as follows; Illustration b in Figure 13.4H:

   a. Minor Road. The assumed turning speed from the minor road to the major road is 10 mph (16 km/h). This corresponds to an approach distance of 82' (25 m) along the minor road leg.

   b. Major Road. To determine the legs along the major road, use the same procedures as discussed in Section 13.4.2.2 for the stop controlled intersection, Equation 13.4-1 and the gap acceptance time listed in Figure 13.4J. Because the gap acceptance time are longer than the stop-controlled gap times, it will be unnecessary to determine the sight distance criteria for the vehicle which stops at the yield sign.

Design Vehicle	Gap Acceptance Time (t_g)(sec)
Passenger Car	8.0
Single-Unit Truck	10.0
Tractor/Semitrailer	12.0

Adjustments:

If the approach grade on the minor road exceeds 3%, the following applies:

1. *For right turns, multiply the percent grade of the minor road approach by 0.1 and add it to the base gap acceptance time.*
2. *For left turns, multiply the percent grade of the minor road approach by 0.2 and add it to the base gap acceptance time.*

GAP ACCEPTANCE TIMES FOR YIELD CONTROL INTERSECTIONS (Turning Maneuvers)

Figure 13.4J

13.4.4 All-Way Stop

At intersections with all-way stop control, provide sufficient sight distance so that the first stopped vehicle on each approach is visible to all other approaches. The ISD criteria for left or right-turning vehicles as discussed in Section 13.4.2 are not applicable in this situation. Often, intersections are converted to all-way stop control to address limited sight distance at the intersection. Therefore, providing additional sight distance at the intersection is unnecessary.

13.4.5 Stopped Vehicle Turning Left

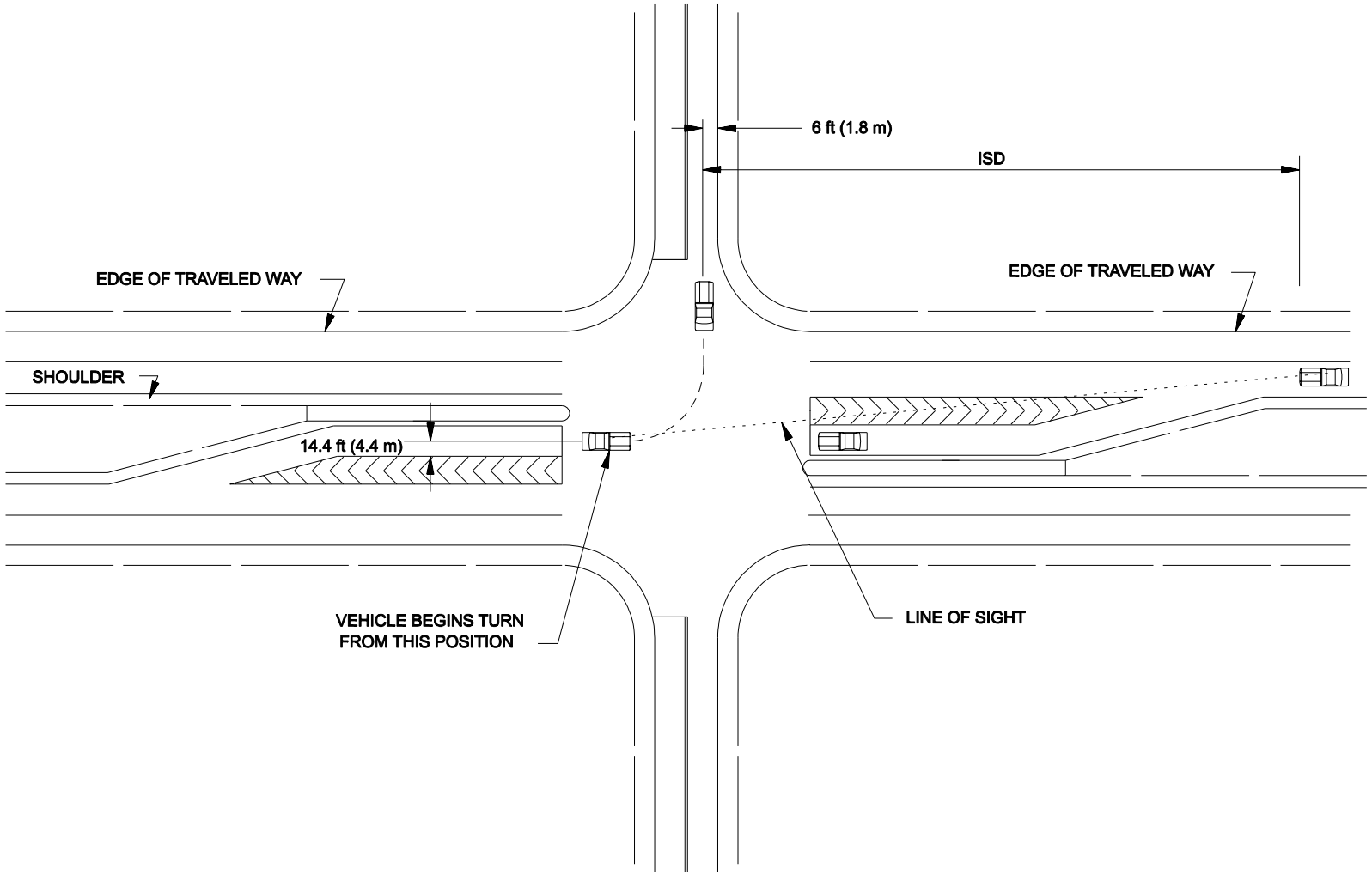
At all intersections, regardless of the type of traffic control, the designer should consider the sight distance needs for a stopped vehicle turning left from the major road. This is illustrated in Figure 13.4K. The driver must see straight ahead for a sufficient distance to turn left and clear the opposing travel lanes before an approaching vehicle reaches the intersection. In general, if the major highway has been designed to meet the stopping sight distance criteria, intersection sight distance only will be a concern where the major road is on a horizontal curve, where there is a median, or where there are opposing vehicles making left turns at an intersection.

Use Equation 13.4-1 (Page 13.4(5)) and the gap acceptance times (t_g) from Figure 13.4L to determine the applicable intersection sight distances for the left-turning vehicle. Where the crossing vehicle must cross more than one lane, add 0.5 seconds for passenger cars or 0.7 seconds for trucks for each additional lane in excess of one. Where medians are present, the designer will need to consider their effect in the same manner as discussed in Section 13.4.2.2. Figure 13.4M provides the ISD values for all design vehicles and two common left-turning situations.

13.4.6 Measures to Improve Intersection Sight Distance

The available ISD should be checked using the above noted parameters. If the ISD values from the above Sections are provided, no further investigation is needed. If the line of sight is restricted by either bridge railing, guardrail, other obstructions, or the horizontal and vertical alignment of the main road and the ISD value is not available, evaluate one or more of the following modifications, or a combination, to achieve the intersection sight distance:

1. remove the obstructions that are restricting the sight distance,
2. relocate the intersecting road farther from the end of the bridge,
3. widen the structure on the side where the railing is restricting the line of sight,
4. flare the approach guardrail,
5. revise the grades on the main road and/or the intersecting road,
6. close the intersecting road,
7. make the intersecting road one-way away from the main road, and/or
8. review other measures that may be practical at a particular location.



Notes:

1. See Figure 13.4M for ISD values.
2. See Section 13.4.5 for discussion and application.

INTERSECTION SIGHT DISTANCE FOR A STOPPED VEHICLE TURNING LEFT
(On Major Road)

Figure 13.4K

Design Vehicle	Gap Acceptance Time (t_g)(sec)
Passenger Car	5.5
Single-Unit Truck	6.5
Tractor/Semi-trailer	7.5

GAP ACCEPTANCE TIMES
(Left-Turning Vehicles from Major Road)

Figure 13.4L

U.S. Customary (Rounded for design)

Design Speed (Vmajor) (mph)	ISD (ft)					
	Passenger Cars		Single-Unit Trucks		Tractor/Semitrailers	
	Crossing 1 lane	Crossing 2 lanes	Crossing 1 lane	Crossing 2 lanes	Crossing 1 lane	Crossing 2 lanes
20	165	180	195	215	225	245
25	205	225	240	265	280	305
30	245	265	290	320	335	365
35	285	310	335	375	390	425
40	325	355	385	425	445	485
45	365	400	430	480	500	545
50	405	445	480	530	555	605
55	445	490	530	585	610	665
60	490	530	575	640	665	725
65	530	575	625	690	720	785
70	570	620	670	745	775	845
75	610	665	720	795	830	905
80	650	710	765	850	885	965

Metric (Rounded for design)

Design Speed (Vmajor) (km/h)	ISD (m)					
	Passenger Cars		Single-Unit Trucks		Tractor/Semitrailers	
	Crossing 1 lane	Crossing 2 lanes	Crossing 1 lane	Crossing 2 lanes	Crossing 1 lane	Crossing 2 lanes
30	50	55	55	65	65	70
40	65	70	75	85	85	95
50	80	85	95	105	105	115
60	95	105	110	125	130	140
70	110	120	130	145	150	160
80	125	135	145	165	170	185
90	140	155	165	185	190	210
100	155	170	185	205	210	230
110	170	185	200	225	230	255

INTERSECTION SIGHT DISTANCES
(Left-Turning Vehicles from Major Road))

Figure 13.4M